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ACCURACY OF A COMMERCIALLY AVAILABLE TELEMETRY SYSTEM TO MEASURE CORE TEMPERATURE DURING EXERCISE WHEN WEARING CHEMICAL PROTECTIVE CLOTHING

U S ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

Natick, Massachusetts

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UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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Core temperature was measured by an esophageal thermistor and by an ingestible telemetry pill (Cortemp™, Human Technologies Inc., St. Petersburg, FL) during moderate exercise in women wearing a chemical protective clothing ensemble with a high thermal resistance (R_T, 0.4 $m^{-2}\cdot K^{-1}\cdot W^{-1}$). Telemetry pills were calibrated against a Hewlett Packard™ quartz thermometer the day prior to ingestion. Telemetry pills were ingested two hours before testing; pill ingestion was followed by a light meal. The esophageal thermistor was inserted to a length that was 25% of the standing height and adjusted to a previously determined "hot spot". Resting esophageal temperature (T_{es}) averaged 37.11±0.21°C and resting pill temperature (T_{pill}) averaged 37.17±0.27°C. The combination of exercise (225±30 $W\cdot m^{-2}$), clothing and ambient temperature (T_a = 30°C) caused T_{es} to increase to an average of 38.67±0.28°C and T_{pill} to increase to an average of 38.71±0.33°C during the hour of treadmill walking. The two temperature measurements were compared by least squares regression techniques. For the eight individual experiments run, the regression coefficient (r) averaged 0.98±0.01. The calibrated temperature sensor ingested in these experiments provided accurate, usable core temperature data during logistically difficult experimental conditions.

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ACCURACY OF A COMMERCIALLY AVAILABLE TELEMETRY SYSTEM TO MEASURE CORE TEMPERATURE DURING EXERCISE WHEN WEARING CHEMICAL PROTECTIVE CLOTHING

by

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January 1997

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FOREWORD

Heat exposure necessitates activation of thermoregulatory effector mechanisms to maintain core temperature. If core and skin temperatures increase, heat loss mechanisms are activated and increased sweat secretion and increased blood flow to the skin surface occur to eliminate body heat. The time an individual can tolerate work in the heat is decreased by the fabric barriers inherent in protective clothing systems. If heat transfer from the body surface via convection and evaporation is decreased, thermoregulatory heat balance is compromised. The rate of heat storage increases when subjects wear chemical protective clothing systems because the micro-environment at the skin surface (high water vapor content) impairs evaporative heat exchange, and the physical characteristics of the chemical protective clothing limit dry or sensible heat transfer.

There is always potential for heat stress in soldiers wearing chemical protective clothing. For this reason an unobtrusive and reliable measurement of core temperature has been sought by USAMRMC for monitoring human safety. USAMRMC has historically provided funding for telemetry research (Redmond *et al.*, 1992). The measurement of deep core temperature for research purposes or clinical safety is generally done using either esophageal or rectal temperature. Both temperatures are reproducible and not biased by environmental temperature. Telemetry systems offer a means to monitor core temperature using a swallowed "pill" as a sensor which transmits temperature information outside of the body. This technology is useful, especially for monitoring the safety of subjects in situations where, either clothing fully encapsulates the subject, prolonged

monitoring is required or hardwiring is not possible. This research was done to determine the accuracy of a temperature sensor and telemetry system as compared to esophageal temperature. The comparison was made from core temperature data collected from exercising women who were dressed in chemical protective clothing.

ACKNOWLEDGMENTS

This work would not have been possible without the volunteers who participated in the tests described in this report. We wish to thank them for their time and effort. We especially thank Dr. C. Gabarée, J. De Luca, B.S. Cadarette and B. Mair for their contributions to these studies.

EXECUTIVE SUMMARY

Core temperature was measured by an esophageal thermistor and by an ingestible telemetry pill (Cortemp™, Human Technologies Inc., St. Petersburg, FL) during moderate exercise in women wearing a chemical protective clothing ensemble with a high thermal resistance (R_T, 0.4 $m^{-2} \cdot K^{-1} \cdot W^{-1}$). Telemetry pills were calibrated against a Hewlett Packard™ quartz thermometer the day prior to ingestion. Telemetry pills were ingested two hours before testing; pill ingestion was followed by a light meal. The esophageal thermistor was inserted to a length that was 25% of the standing height and adjusted to a previously determined "hot spot". Resting esophageal temperature (T_{es}) averaged 37.11±0.21°C and resting pill temperature (T_{pill}) averaged 37.17±0.27°C. The combination of exercise (225±30 $W \cdot m^{-2}$), clothing and ambient temperature (T_a = 30°C) caused T_{es} to increase to an average of 38.67±0.28°C and T_{pill} to increase to an average of 38.71±0.33°C during the hour of treadmill walking. The two temperature measurements were compared by least squares regression techniques. For the eight individual experiments run, the regression coefficient (r) averaged 0.98±0.01. The calibrated temperature sensor ingested in these experiments provided accurate, usable core temperature data during logistically difficult experimental conditions.

INTRODUCTION

The measurement of core temperature for research purposes or clinical safety is generally done using either esophageal or rectal temperature. Both temperatures are reproducible and not biased by environmental temperature (Brenglemann, 1987; Gerbrandy *et al.*, 1954; Mead *et al.*, 1949); however, the slow response time of rectal temperature is well documented (Eichna *et al.*, 1951; Gerbrandy *et al.*, 1954; Kolka *et al.*, 1987; Mittleman *et al.*, 1988; Molnar *et al.*, 1974). Esophageal temperature is an ideal method for tracking blood temperature in the right heart as it most accurately reflects the integrated temperature of the pre-optic/anterior hypothalamus. Consequently, it responds very quickly to dynamic changes in mean body temperature (Brenglemann, 1987; Gerbrandy *et al.*, 1954; Rowell, 1983; Shiraki *et al.*, 1986; Shiraki *et al.*, 1988). Telemetry systems offer a means to monitor core temperature using a swallowed "pill" as a sensor which transmits temperature information to a receiver outside of the body.

Chemical protective overgarments, fire protective garments, and toxic site cleanup garments worn by military or civilian personnel create a logistically difficult situation in which to safely and accurately monitor the core temperature of these individuals. In these workers, heat strain is a major problem as core temperature continues to increase because the heat produced by muscular work and/or environmental conditions cannot be dissipated through the clothing system. Telemetry technology is useful, especially for monitoring the safety of subjects in situations where, either clothing fully encapsulates the subject, prolonged monitoring is required or hardwiring is not possible (Mackay, 1970; Wolff,

1961; Redmond *et al.*, 1992). Telemetry technology has been used previously to measure core temperature in human subjects in various experimental protocols (Fox *et al.*, 1961; Gibson *et al.*, 1981; Mittal *et al.*, 1991; Sparling *et al.*, 1993; Stephenson *et al.*, 1992; Kolka *et al.*, 1993).

STATEMENT OF PURPOSE

The purpose of this study was to compare how well a commercially available temperature telemetry system tracked rapid changes in core temperature compared with esophageal temperature during exercise in subjects wearing a chemical protective clothing ensemble which limited both evaporative heat transfer and dry heat transfer, allowing continued heat storage during the experiment.

METHODS

Four women volunteered to serve as test subjects after they were informed of the purpose, procedures, and known risks of this study. Each signed a consent form describing the study which was approved by appropriate human use review committees. The average (±SD) age was 25.6±9.6 yr, height was 1.68±0.05 m, mass was 63.0±11.0 kg, DuBois surface area was 1.71± 0.15 m^2 and maximal aerobic power was 2.66±0.30 $L \cdot min^{-1}$.

Two methods were used to measure core temperature: esophageal temperature (T_{es}), and pill temperature (CorTemp™, Human Technologies, Inc., St. Petersburg, FL ingestible temperature sensor). Esophageal temperature was measured at a pre-determined location in the esophagus deemed the "hot spot" using a calibrated thermistor. The "hot spot" was located by systematically determining temperature in the esophagus beginning at approximately 25% of each volunteer's height until the temperature was at a peak, presumably due to the proximity to the great vessels of the heart. The CorTemp™ telemetry system included an ingestible temperature sensor (2 cm by 1.3 cm in diameter), FM antenna and data recorder system. The calibrated temperature sensor included a silver oxide battery (1.5 V) which provided the power for sensing and transmitting temperature. The components of the sensors were encapsulated in epoxy and covered with silicone rubber. Temperature was transmitted through the body to a double bandoleer-type antenna and recorded by a data logger.

All exercise testing occurred between 0730 and 0900 h. Each subject was tested on 1-3 occasions. Upon arrival at the laboratory the volunteer swallowed the telemetry pill with water and ate a light breakfast. Two (±0.5) hours after swallowing the pill, the volunteer was taken to the environmental test chamber and inserted the esophageal temperature probe.

After instrumentation, each subject dressed in chemical protective clothing (modified MOPP 4: BDU, overgarment, overboots, hood, gloves, open mask for metabolic rate measurements and to accommodate the esophageal thermocouple). After complete instrumentation and dressing, the antenna for the telemetry system was attached to the subject's torso, and then she sat in a chair which was positioned on the treadmill. After equilibration with the environment (15-30 min), treadmill exercise began and continued for 60 minutes. The ambient temperature in the environmental test chamber was 30°C and the dew point temperature was 11.5°C. Esophageal temperature and pill temperature were measured every 30 s throughout the experiment. Heart rate was measured at 5 min intervals by electrocardiography.

Subject Safety

All of the procedures in this study fell within the framework, restrictions and safety limitations of the USARIEM Type Protocol for Human Research Studies in the areas of

Thermal, Hypoxic and Operational Stress, Exercise, Nutrition and Military Performance, which was in effect at the time when the research was done.[1]

STATISTICAL ANALYSES

Esophageal temperature and pill temperature were compared at rest and during exercise by analysis of variance procedures with repeated measures. In addition, esophageal temperature and pill temperature data were compared by least squares regression techniques.

[1]Approved 14 Dec 1994. The type protocol provides information and explanations about conditions, standards and safeguards, in order to serve as an encompassing framework for specific in-house studies in its general subject area. It is to be used as a reference to facilitate the understanding and review of specific study protocols which conform to its provisions, and thus do not exceed the degree of risk, and safety limits herein stipulated (reference para 18, USAMRMC Reg 70-25).

RESULTS AND DISCUSSION

A published report (Kolka *et al.*, 1993) documented the limitations of the telemetry technique during laboratory experiments. The pitfalls in the use of two different telemetry methods for monitoring core temperature (Stephenson *et al.*, 1992) included capturing telemetry data (experimental telemetry), slow responding temperature sensor (experimental telemetry) and movement of the sensor (experimental and CorTemp™ telemetry) in the gastrointestinal system. The promising results using the CorTemp™ system in the previous study (Stephenson *et al.*, 1992) prompted us to continue testing this device in a more difficult scenario. The data from the current study suggest that under controlled experimental conditions, this commercially available, off-the-shelf system, can be used for effective, accurate core temperature measurements in encapsulated human volunteers.

The primary purpose of this study was to evaluate the data from a temperature pill telemetry system and determine whether the data provided an accurate index of core temperature in fully encapsulated subjects. Experiments were run under severe conditions created by a combination of exercise intensity, clothing with a high thermal resistance and low evaporative capacity, and warm environmental conditions. This combination caused core temperature to increase ~1.5°C in 60 minutes, during which time skin temperature remained above 36°C and heart rate approached 170 $b{\bullet}min^{-1}$. Resting esophageal temperature averaged 37.11±0.21°C and resting pill temperature averaged 37.17±0.27°C. The combination of exercise (225±30 $W{\cdot}m^{-2}$), clothing and ambient temperature (T_a =

30°C) increased esophageal temperature to an average of 38.67±0.28°C and pill temperature to an average of 38.71±0.33°C during the hour of treadmill walking. The pattern of esophageal temperature and pill temperature for all eight experiments is shown in Figures 1 and 2. In many of the experiments (Figures 1 and 2) there are aberrant data points from the telemetry sensors. These occurred because of difficulties with the antennae and receivers, not because telemetry sensor signal was lost. Improvements in reception of telemetered signal have been made and are currently ongoing. The comparison of the two temperature measurements by least squares regression techniques (r) is shown in Figures 3 and 4. For the eight individual experiments run, the r averaged 0.98 ± 0.01 (Table 1).

Esophageal temperature was measured in this study because it responds rapidly to changes in body temperature (Brenglemann, 1987; Gerbrandy *et al.*, 1954; Rowell, 1983; Shiraki *et al.*, 1986; Shiraki *et al.*, 1988). Tympanic or auditory meatus temperature has been used as an index of internal body temperature in laboratory studies (Baker *et al.*, 1972; Greenleaf *et al.*, 1972; Sharkey *et al.*, 1987; Shiraki *et al.*, 1986; Shiraki *et al.*, 1988). The main detraction for using tympanic temperature and the reason this index was not used in the current study, is that tympanic temperature more reliably tracks skin temperature than core temperature in humans (Greenleaf *et al.*, 1972; Sharkey *et al.*, 1987; Shiraki *et al.*, 1986). Initially, tympanic temperature was used because it responded similarly to brain temperature in the monkey and the cat (Baker *et al.*, 1972), and it was proposed that tympanic temperature was the best core temperature index in humans

because it more accurately reflects hypothalamic temperature and would also account for selective brain cooling (Brinnel *et al.*, 1989; Cabanac, 1986; Cabanac *et al.*, 1979). However, the existence of selective brain cooling in humans has not been proven and remains highly controversial (Cabanac, 1986; Nadel, 1987; Wenger, 1987; Jessen and Kuhnen, 1992).

The environmental conditions imposed on the subjects in the study limited dry heat flux between the skin and the clothing, and limited dry heat flux through the clothing. Heat loss in warm environments during exercise occurs by evaporative heat loss, but the relatively non-porous clothing worn by our subjects resisted transmission of water vapor. In these experiments, all subjects continued to store heat during exercise with no leveling off of internal temperature (Figures 1 and 2). It is clear that T_{pill} (Table 1) is an accurate index of core temperature under the conditions of this study.

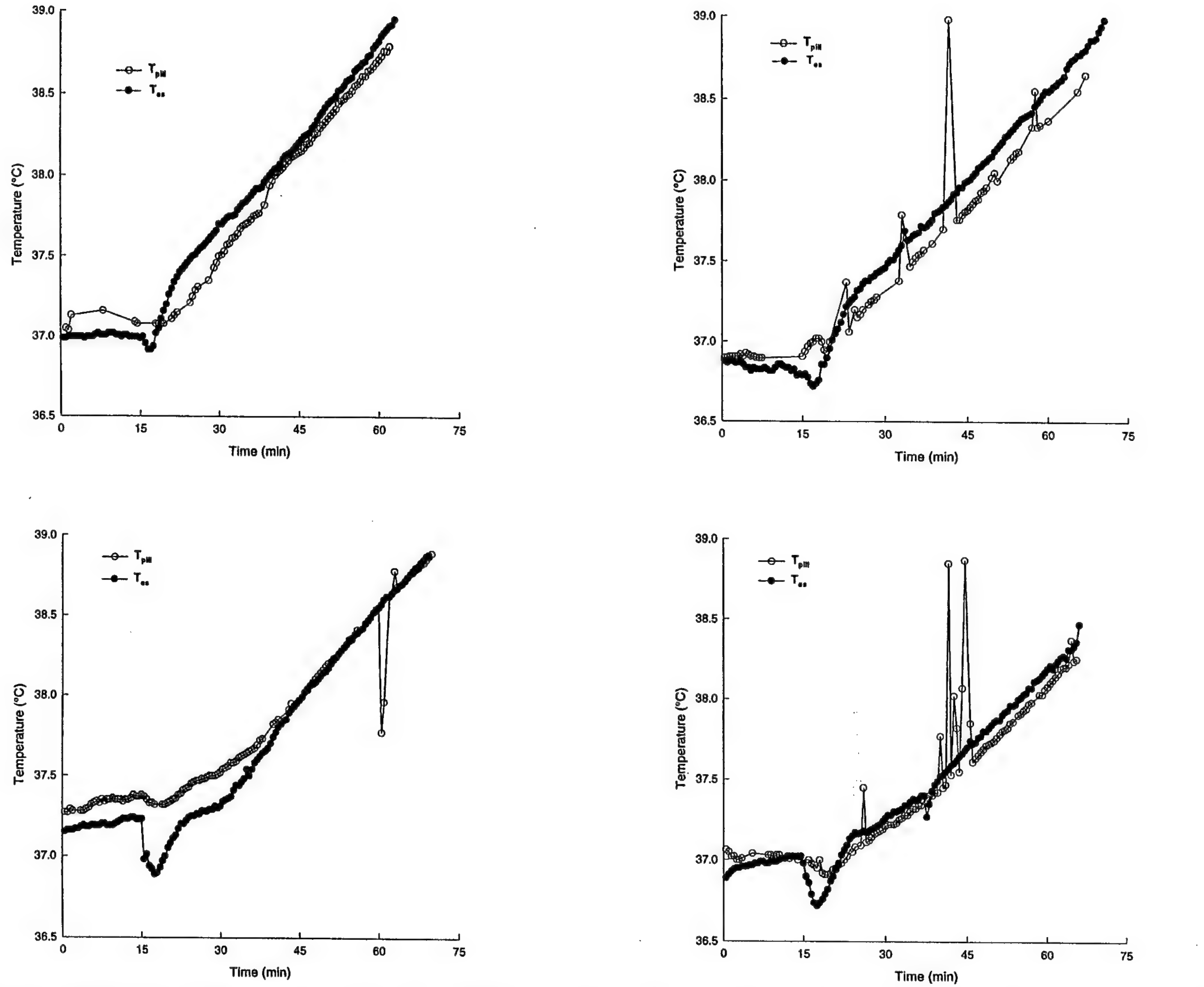

Figure 1: Esophageal temperature (T_{es}) and telemetered sensor temperature (T_{pill}) during experiments 1-4 in women wearing a relatively impermeable clothing ensemble during treadmill exercise.

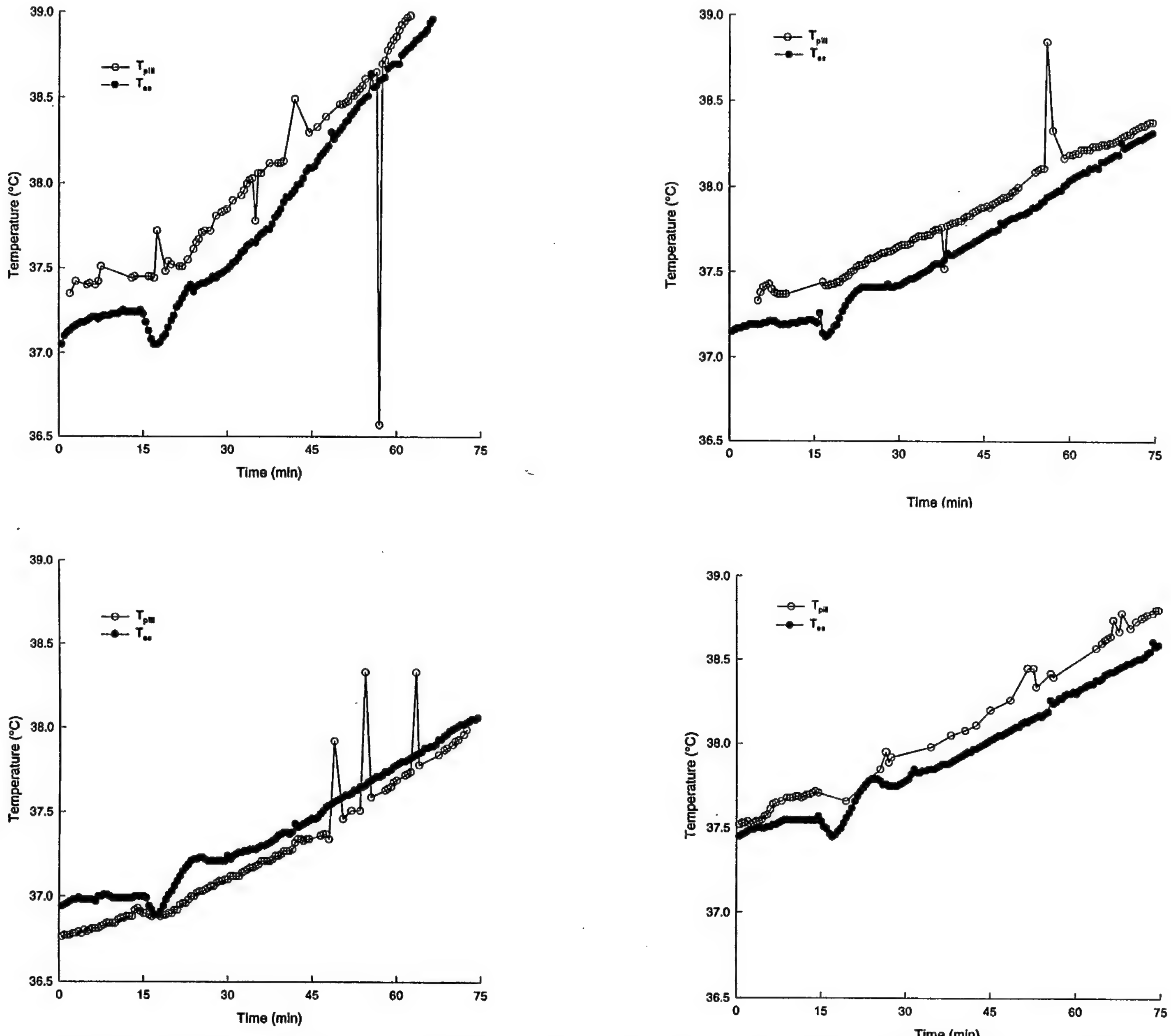

Figure 2: Esophageal temperature (T_{es}) and telemetered sensor temperature (T_{pill}) during experiments 5-8 in women wearing a relatively impermeable clothing ensemble during treadmill exercise.

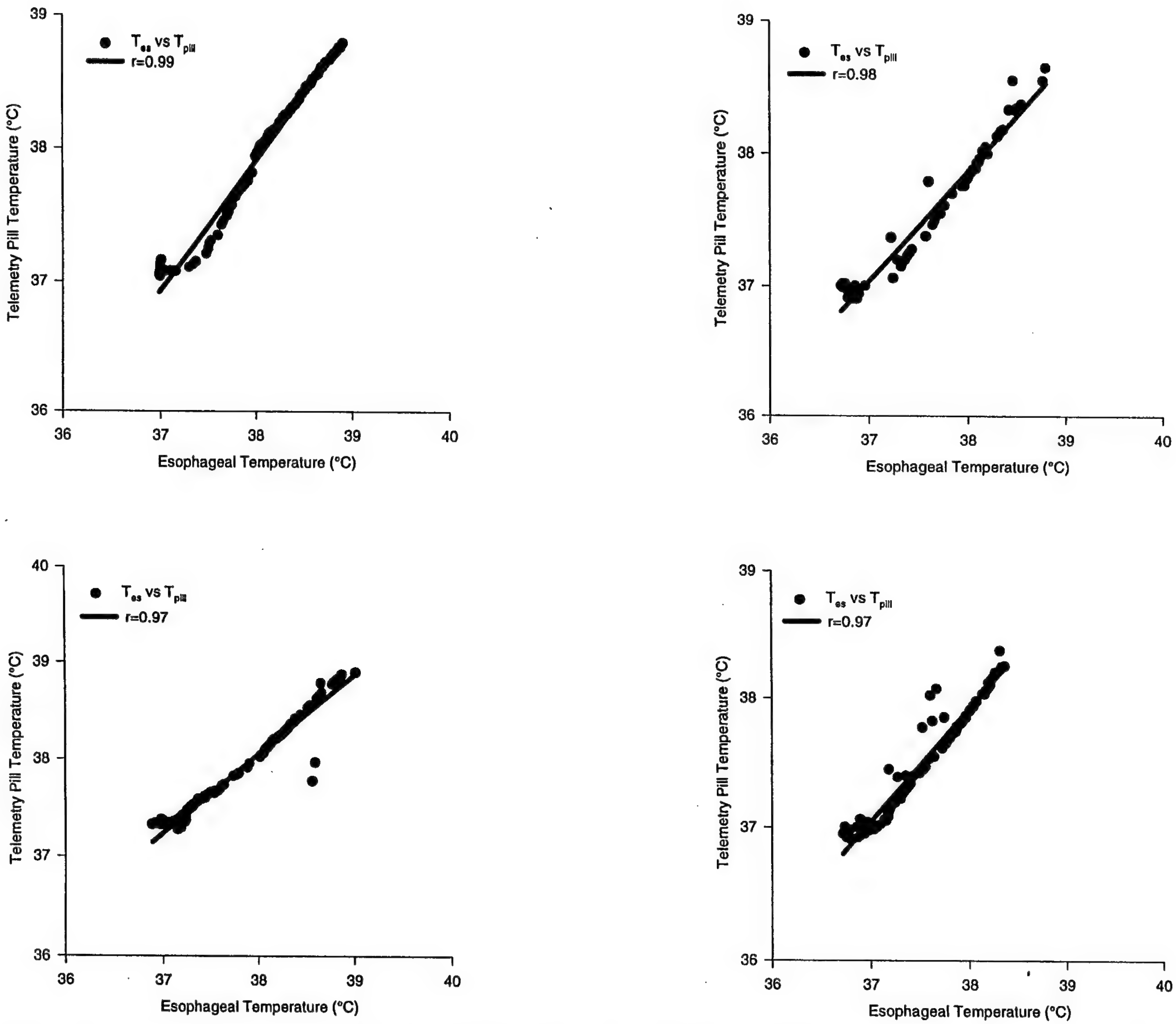

Figure 3: The linear relationship between esophageal temperature (T_{es}, X axis) and telemetered sensor temperature (T_{pill}, Y axis) during experiments 1-4 in women wearing a relatively impermeable clothing ensemble during treadmill exercise.

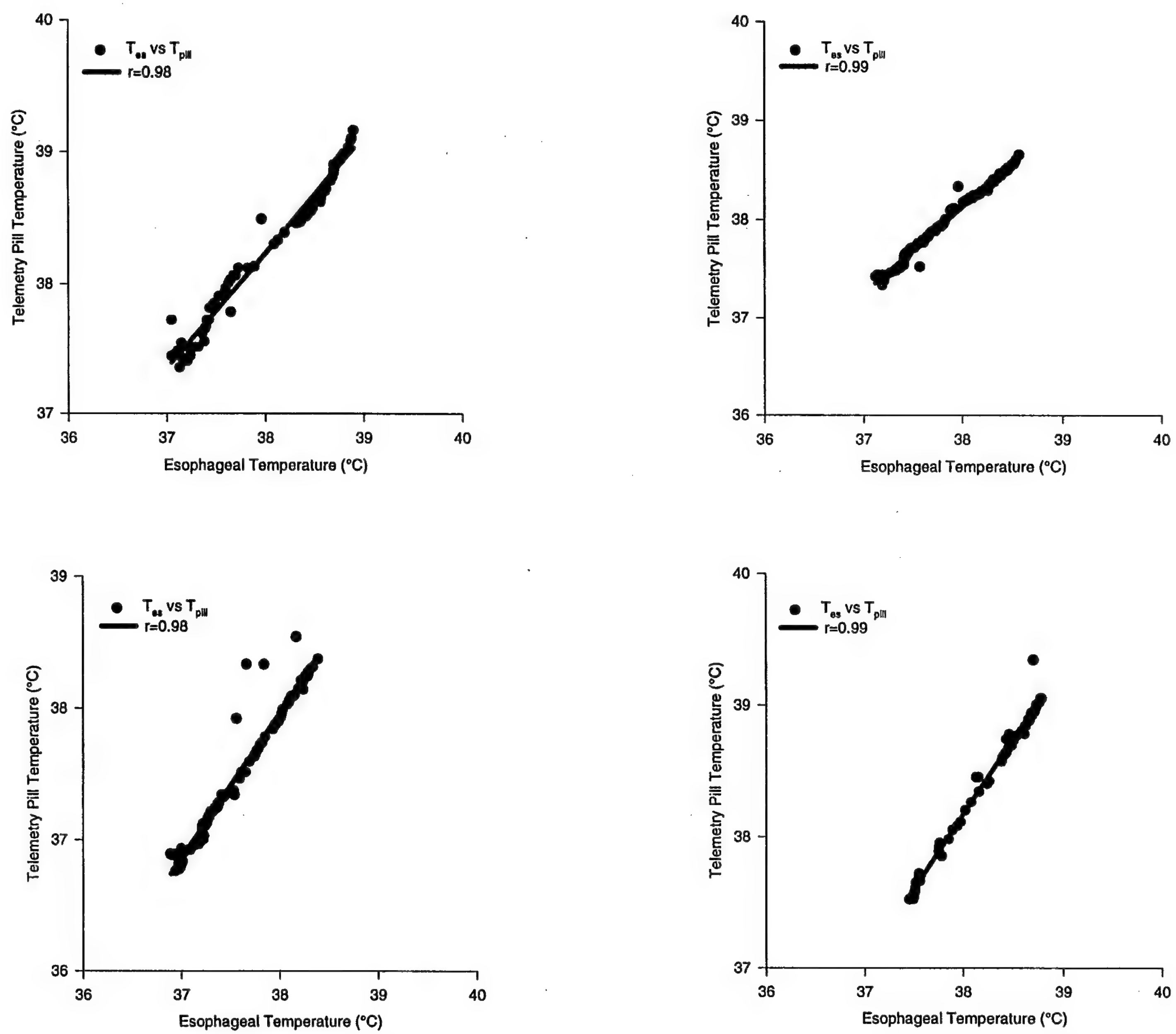

Figure 4: The linear relationship between esophageal temperature (T_{es}, X axis) and telemetered sensor temperature (T_{pill}, Y axis) during experiments 5-8 in women wearing a relatively impermeable clothing ensemble during treadmill exercise.

Table 1. Regression coefficients for the eight experiments comparing esophageal temperature (X variable) and pill temperature (Y variable).

Experiment	r	slope	Y-intercept
1	0.99	0.980	0.674
2	0.98	0.828	6.401
3	0.97	0.816	7.020
4	0.97	0.879	4.512
5	0.98	0.885	4.612
6	0.99	0.877	4.850
7	0.98	1.103	-3.948
8	0.99	1.140	-5.147

CONCLUSIONS

In this study, pill temperature was not different than esophageal temperature during exercise, and the total change in pill temperature during the 60 min experiment was not significantly different than the change in esophageal temperature. In conclusion, the telemetry system as a core temperature data acquisition system was reliable, provided that preliminary screening by water bath calibration eliminated those sensors (pills) which measured temperature inaccurately. For the most part, the telemetry system accurately measured core temperature. The concept of using a temperature sensor in a pill is useful (Wolff, 1961) if care is taken to 1) calibrate and test the sensor before ingestion; 2) locate the sensor, through time of ingestion, in the appropriate portion of the gastrointestinal tract useful for the specific protocol; a small meal given with ingestion can aid passing the pill out of the stomach; and 3) monitor receiver location so that all data are collected.

REFERENCES

Baker M.A., Stocking R.A., and Meehan J.P. (1972) Thermal relationship between tympanic membrane and hypothalamus in conscious cat and monkey. Journal of Applied Physiology 32, 739-742.

Brengelmann G.L. (1987) Dilemma of body temperature measurement. In:Man in Stressful Environments. Thermal and Work Physiology. edited by K. Shiraki, and M. K. Yousef. Springfield, IL: Charles C. Thomas, pp. 5-22.

Brinnel H., and Cabanac M. (1989) Tympanic temperature is a core temperature in humans. Journal of Thermal Biology 14, 47-53.

Cabanac M. (1986) Keeping a cool head. News in Physiological Sciences 1, 41-44.

Cabanac M., and Caputa M. (1979) Natural selective cooling of the human brain: evidence of its occurrence and magnitude. Journal of Physiology (London) 286, 255-264.

Eichna L.W., Berger A.R., Rader B., and Becker W.H. (1951) Comparison of intracardiac and intravascular temperatures with rectal temperatures in man. Journal of Clinical Investigation 30, 353-359.

Fox R.H., Goldsmith R. and Wolff H.S. (1961) The use of a radio pill to measure deep body temperature. Journal of Physiology (London) 160, 22-23.

Gerbrandy J., Snell E.S., and Cranston W.I. (1954) Oral, rectal and oesophageal temperatures in relation to central temperature control in man. Clinical Sciences 13, 615-624.

Gibson T.M., Redman P.J. and Belyavin A.J. (1981) Prediction of oesophageal temperatures from core temperatures measured at other sites in man. Clinical Physical and Physiological Measures 2, 247-256.

Greenleaf J.E., and Castle B.L. (1972) External auditory canal temperature as an estimate of core temperature. Journal of Applied Physiology 32, 194-198.

Jessen C., and Kuhnen G. (1992) No evidence for brain stem cooling during face fanning in humans. Journal of Applied Physiology 72, 664-669.

Kolka M.A., Stephenson L.A., Bruttig S.P., Cadarette B.S., and Gonzalez R.R. (1987) Human thermoregulation after atropine and/or pralidoxime administration. Aviation, Space and Environmental Medicine 58, 545-549.

Kolka M.A., Quigley M.D., Blanchard L.A., Toyota D.A., and Stephenson L.A. (1993) Validation of a temperature telemetry system during moderate and strenuous exercise. Journal of Thermal Biology 18:203-210.

Mackay R.S. (1970) Bio-Medical Telemetry. Second Ed., New York: John Wiley & Sons, Inc., pp. 154-159.

Mead J., and Bonmarito C.L. (1949) Reliability of rectal temperatures as an index of internal body temperature. Journal of Applied Physiology 2, 97-109.

Mittal B.B., Sathiaseelan V., Rademaker A.W., Pierce M.C., Johnson P.M. and Brand W.N. (1991) Evaluation of an ingestible telemetric temperature sensor for deep hyperthermia applications. International Journal of Radiation Oncology in Biology and Physiology 21, 1353-1361.

Mittleman K.D., and Mekjavic I.B. (1988) Effect of occluded venous return on core temperature during cold water immersion. Journal of Applied Physiology 65, 2709-2713.

Molnar G.W., and Read R.C. (1974) Studies during open-heart surgery on the special characteristics of rectal temperature. Journal of Applied Physiology 36, 333-336.

Nadel E.R. (1987) Comments on "Keeping a cool head" by M. Cabanac. News in Physiological Sciences 2, 33.

Redmond D., Leu, J.C., Popp K.A., Gutierrez P.E. and Hall S.W., Jr. (1990) The Walter Reed temperature pill: Evaluations for clinical and investigational usage. Walter Reed Army Institute of Research Technical Report.

Rowell L.B. (1983) Cardiovascular adjustments to thermal stress. In: Handbook of Physiology-The Cardiovascular System III, edited by J. T. Shepherd and F. M. Abboud. Bethesda: Am. Physiol. Soc., Chapter 27, pp.967-1023.

Sharkey A., Elliott P., Lipton J.M., and Giesecke A.H. (1987) The temperature of the air within the external auditory meatus compared with esophageal temperature during anaesthesia and surgery. Journal of Thermal Biology 12, 11-13.

Shiraki K., Konda N., and Sagawa S. (1986) Esophageal and tympanic temperature responses to core blood temperature changes during hyperthermia. Journal of Applied Physiology 61, 98-102.

Shiraki K., Sagawa S., Tajima F., Yokota A., Hashimoto M., and Brengelmann G.L. (1988) Independence of brain and tympanic temperatures in an unanesthetized human. Journal of Applied Physiology 65, 482-486.

Sparling P.B., Snow T.K., and Millard-Stafford M. (1993) Monitoring core temperature during exercise: ingestible sensor vs rectal thermistor. Aviation, Space and Environmental Medicine 64, 760-763.

Stephenson L.A., Quigley M.D., Blanchard L. A., Toyota D.A. and Kolka M.A. (1992) Validation of two telemetry pill systems in humans during moderate and strenuous exercise. US Army Research Institute of Environmental Medicine Technical Report, T10\92.

Wenger C.B. (1987) More comments on "Keeping a cool head" by M. Cabanac. News in Physiological Sciences 2, 150.

Wolff H.S. (1961) The radio pill. New Scientist 16, 419-421.

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